

Laboratory Generation of Rayleigh Fading

L. N. RATHNAYAKE

Thesis submitted
to
the University of Moratuwa, Sri Lanka



in partial fulfillment of the requirement for the degree of
Master of Engineering
in
Electronics & Telecommunications

September 2006

University of Moratuwa



87135

87135

621.38⁰⁶
621.38(043)

87135

The work presented in this dissertation has not been
submitted for the fulfillment of any other degree



University of Moratuwa, Sri Lanka
Electronic Theses & Dissertations
www.lib.mrt.ac.lk

...L N Rathnayake..
L N Rathnayake
Candidate

.....Dileeka Dias.....
Prof (Mrs.) Dileeka Dias
Supervisor

Acknowledgements

I am very thankful to my supervisor Prof (Mrs.) Dileeka Dias for the guidance and support given to me by her during the pursuit of my Master's degree. She has been very helpful and I am grateful for her willingness and readiness in giving direction to my thesis work.

I would like to thank Mr. Chandana Peiris for his invaluable ideas and suggestions during the course of my thesis work.

Last, but not least, I would like to thank my family who were a source of constant support and encouragement.

Abstract

Mobile radio channel simulators are essential for repeatable system tests in a development, design, or test laboratory. Due to the random, uncontrollable nature of the mobile propagation path, it is difficult to generate repeatable field test results. Also doing field tests in a mobile environment is considerably more expensive.

An approach for hardware simulation of Rayleigh fading is presented in this thesis. The heart of the simulator is a Digital Signal Processor (DSP), which implements the random noise and the digital filtering necessary for the generation of a Rayleigh faded signal.

The results indicate that the proposed hardware simulator can simulate Rayleigh fading with a high degree of accuracy. The envelope of the generated Rayleigh fading had been observed by an Oscilloscope. The observations have been done also for carrier frequency of 900MHz.

Contents

Acknowledgements	iii
Abstract	iv
List of Figures	vi
Chapter	
1. Introduction	
1.1. Motivation	1
1.2. Previous Related Research	2
1.3. Outline of this Thesis	2
2. Rayleigh Fading Simulator	
2.1. Rayleigh Fading Channel	3
2.2. Channel Simulation Model	9
3. Implementation of Rayleigh Fading Simulator	
3.1. Hardware	11
3.2. FIR Low Pass Filter (LPF)	14
3.3. Linear-Feedback Shift Register (LFSR)	15
3.4. Pseudo-Random Binary Sequence (PRBS) by a LFSR	17
3.5. Generating AWGN source	18
4. Programs and Results	
4.1. Programs	20
4.2. Results	27
5. Discussion of Results & Conclusion	
5.1. Discussion of Results	32
5.2. Conclusion	37
5.3. Directions for Future Work	37
References	38

List of Figures

2.1	A typical mobile situation	3
2.2	A typical Rayleigh fading envelope at 900 MHz Abstract.	4
2.3	Rayleigh probability density function.	5
2.4	Cumulative Distribution Function of a Rayleigh faded envelope.	6
2.5	Effect of Motion.	7
2.6	Faded Power Spectrum.	8
2.7	Theoretical Fade Simulator.	9
2.8	Implemented Rayleigh Fade Simulator.	10
3.1	System Architecture.	12
3.2	ADSP-BF535 EZ-KIT Lite demonstration board.	13
3.3	Digital Low Pass Filter.	14
3.4	4-Bit LFSR, Tap Sequence; [4,1].	15
4.1	Main Flow Chart	20
4.2	Flow chart to obtain the PRBS generated Gaussian Noise.	21
4.3	Setup to display the faded signal on an Oscilloscope.	25
4.4	Filter Response.	27
4.5	Rayleigh Envelope [MATLAB generated noise].	28
4.6	CPDF of Rayleigh envelope [MATLAB generated noise]	28
4.7	Rayleigh Envelope [PRBS generated noise].	29
4.8	CPDF of Rayleigh envelope [PRBS generated noise]	29
4.9	Rayleigh fading envelope at 900 MHz [MATLAB generated noise].	30
4.10	Rayleigh fading envelope at 900 MHz [PRBS generated noise].	31
5.1	Results obtained from Visual DSP++.	35
5.2	Rayleigh Fading envelopes	36